§ 15. Possibility of Transport Barrier Formation by Bursting Toroidal Alfvén Eigenmodes

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Bursting toroidal Alfvén eigenmodes (TAEs) excited in NBI heated plasmas at low field B_t<1T always induce enhanced radial transport and/or loss of energetic ions. Figure 1 shows time evolution of the stored energy W_p measured in such plasma, where W_p is measured with a diagmagnetic loop. As seen from Fig.1, W_p has several small but sharp drops which synchronize with magnetic fluctuation burst related to n=2 TAE. From the power balance for bulk plasma and beam ions generated by tangential NBI (W_p and $W_{b//}$), the relative change of W_p is expressed as,

$$W_p/W_p(0)=\frac{\tau_*}{\tau_s}-\frac{\tau_*(\tau_s-\tau_*)}{\tau_s(\tau_E-\tau_*)}\exp(-\frac{t}{\tau_*})+\frac{\tau_E(\tau_s-\tau_*)}{\tau_s(\tau_E-\tau_*)}\exp(-\frac{t}{\tau_E})$$

where τ_s, τ_E, and τ_c are respectively the slowing down time of beam ions, global energy confinement time and confinement time of energetic beam ion. The time τ_* is expressed as $\tau_*=\frac{\tau_s\tau_c}{\tau_s+\tau_c}$, and $\tau_*\approx\tau_c$ for $\tau_c\ll\tau_s$. From the time evolution of W_p shown in Fig.1 t_c is estimated to be ~3 ms, for instance, at t~1.35 s. Therefore, the loss rate of energetic beam ions $(W_{b//}(0)-W_{b//})/W_{b//}(0)\approx 1-\exp(-\frac{t}{\tau_*})$ is estimated to be 30-50% for each TAE burst.

An interesting fact is found on the time evolution of W_p in Fig.1. That is, W_p rapidly recovers just after the TAE burst and even exceeds that just before the burst. Moreover, electron density and soft X-ray signals in the core region also increase slightly but clearly, synchronizing the W_p-increase, as shown in Fig.2[1]. This suggests the possibility of transport barrier formation induced by TAE burst. Transiently enhanced radial transport and/or loss of energetic ions as shown in Fig.1 may induce radial electric field shear and related poloidal shear flow. This process may be a trigger of transport barrier formation. A reason why the increase in Wp induced by TAE burst is fairly modest may be caused by the presence of rather large damping mechanisms of induced sheared flow. If the flow generation by frequent TAE burst prevails the damping, the rise in W_p by each burst will pile up without the full decay [2]. A typical example of the case is shown in Fig.3.

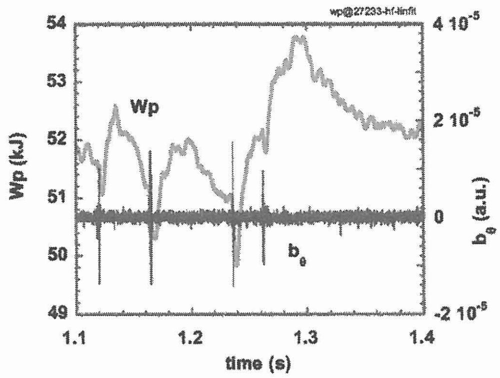

Fig.1 Time evolution of the stored energy W_p in an NBI heated discharge with TAE bursts.

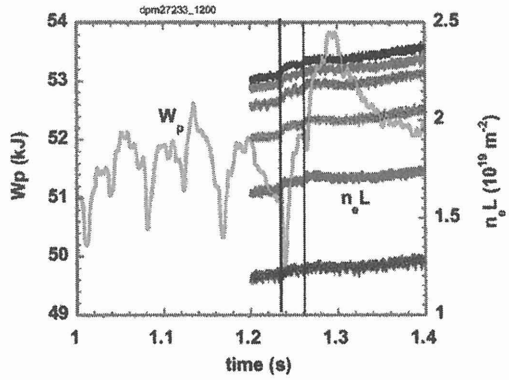

Fig.2 Time evolution of line-integrated electron density for various radial locations together with the bulk plasma energy.

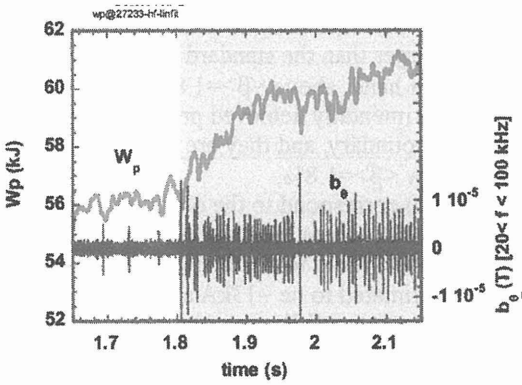

Fig.3 Time evolution of W_p in the phase that TAE burst is frequently excited.

References

[1] K. Toi et al., Proc. 19th IAEA Fusion Energy Conf., Lyon, 2002, paper No. EX/S-32.
[2] GUENTER, S. et al., 28th EPS on Contr. Fusion and Plasma Phys. Funchal, 2001, No.P1-006.